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SHAFT-SINKING METHODS AND COSTS AND COST OF PLANT AND EQUIPMENT AT THE FAD SHAFT, EUREKA CORP., LTD., EUREKA, NEV.

BY

GEORGE W. MITCHELL AND A. C. JOHNSON

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By George W. Mitchell[2] and A. C. Johnson[3]

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1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7495."

2/ General manager, Eureka Corp., Ltd.

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INTRODUCTION

This is one of a series of Information Circulars dealing with the cost of equipping and developing mining properties in the United States, prepared and published by the Bureau of Mines in cooperation with various mining and exploration companies, and designed to supplement an earlier series that covered methods and costs of mining and milling at a large number of producing companies.

ACKNOWLEDGMENT

This type of information circular is prepared by the Mining Branch, Lowell B. Moon, chief.

The authors thank Thayer Lindsley for permission to use data presented in this paper and acknowledge the cooperation of E. J. Martin, mine superintendent, in supplying information on sinking practice and operation of the shaft. The authors also thank Vernon Manz for information on general operations; Tom Kelley for the outline of the mechanical operations involved in sinking operations; William Sharp, engineer, for the maps and general information on the shaft; and J. Murray Riddell for a sketch and information on the Riddell shaft mucker.

PURPOSE OF SHAFT

The shaft is being sunk to develop the ore bodies found by Corporation and Bureau of Mines diamond drilling in the El Dorado dolomite on the hanging wall of the Ruby Hill fault. The Eureka Corp., Ltd., drilled two holes, B and C, from the 900-foot level of the Locan shaft. Both B and C holes penetrated sulfide ore carrying good percentages of zinc and lead and some gold and silver. The ore bodies were 40 feet thick and were found 1,400 feet below the Locan 900-foot level.

On the basis of the favorable results obtained from the drilling program, the Eureka Corp., Ltd., planned extensive development of the property and in

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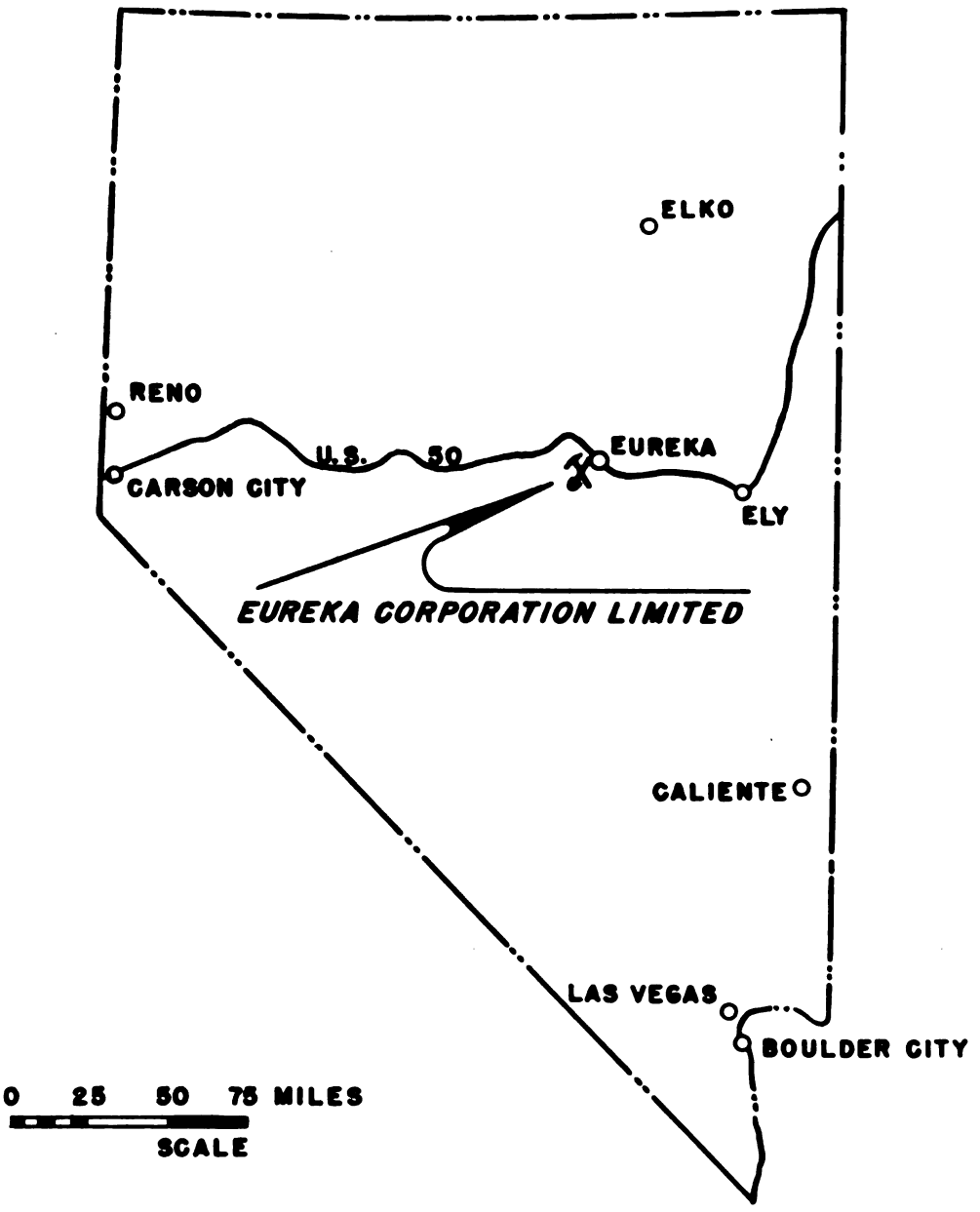

Figure 1. - Location map of Eureka Corp., Ltd., Eureka, Nev.

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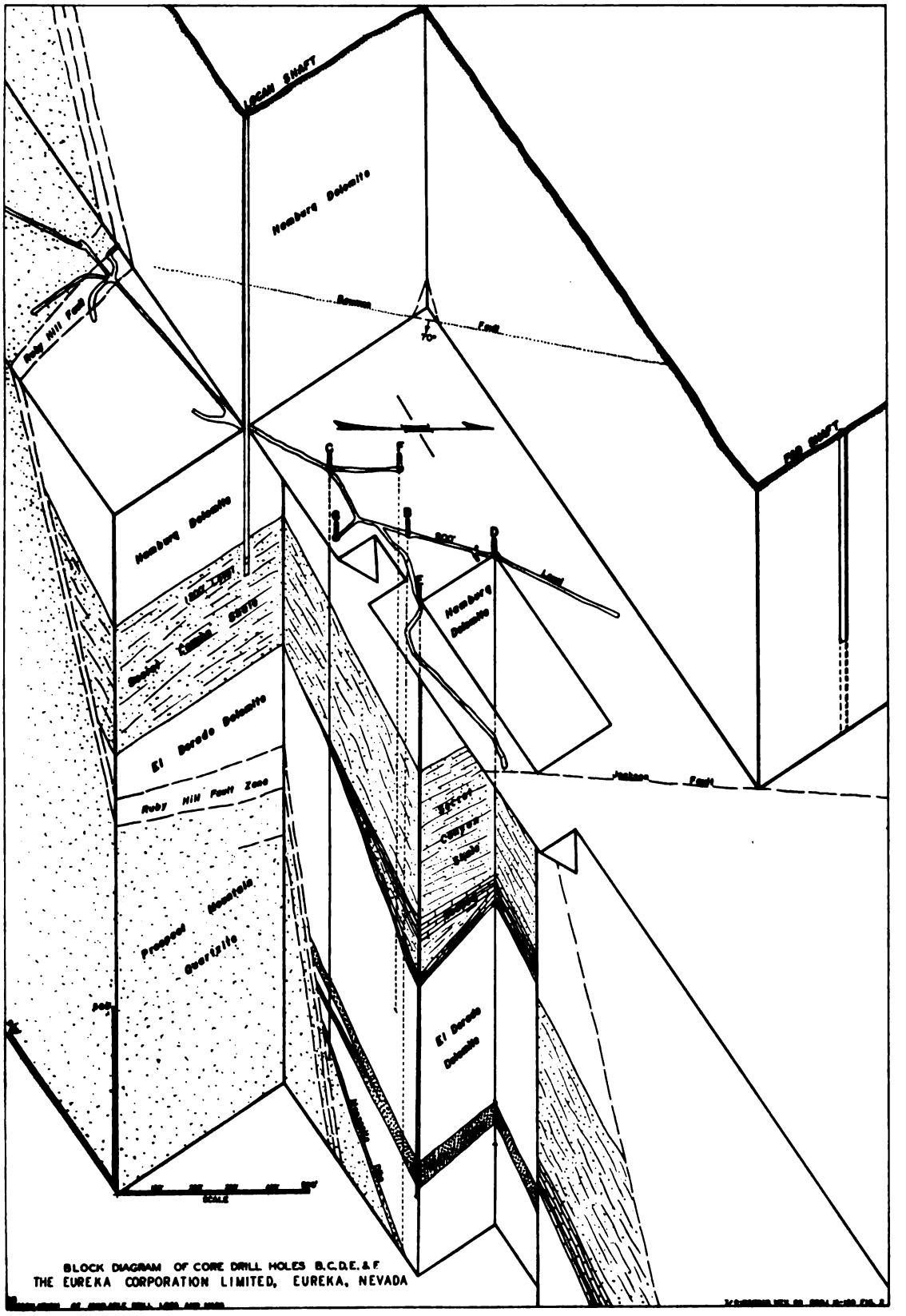

Figure 2. - Block diagram of core drill holes B, C, D, E, and F. The Eureka Corp., Ltd., Eureka, Nev.

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late 1940 commenced sinking the Fad shaft at Eureka, Nev. (Fig. 1.) Shortage of equipment and materials, brought on by the war, and difficulties with water in the shaft greatly hindered progress. In 1943, the Eureka Corp., Ltd., submitted to the War Production Board a proposal to develop the mine and mill 500 tons of zinc-lead ore a day. Before acting on the Corporation's proposal, the War Production Board concluded that further exploration was necessary and requested the Bureau of Mines to examine the mine and recommend a plan to explore the property more fully. As a result of this request, three vertical holes were drilled below the 900-foot level of the Locan shaft and were designated D, E, and F. Ore was penetrated in these three holes.

The holes drilled by the Corporation together with those drilled by the Bureau of Mines formed a pattern enclosing a mineralized area of approximately 350 feet by 300 feet, as shown in figure 2.

Drilling by the Bureau of Mines was under the supervision of E. O. Binyon[4/] project engineer, and gave further proof that mineralization of the El Dorado dolomite continued into the segment that lay on the hanging wall of the Ruby Hill fault between the Jackson and Bowman faults; also, that the ore bodies found by the Corporation in holes B and C were not confined to the immediate vicinity of these holes, but were either continuous or relatively closely spaced in the area blocked by the holes.

ORE DEPOSITS

The geology of the Eureka district has been fully described by Hague[5/] and Curtis.[6/] Walcott[7/] and Resser[8/] wrote several reports covering the fauna found in the Cambrian formation, in which virtually all of the ore deposits occur. Through the work of Wheeler and Lemmon,[9/] a stratigraphic sequence with accurately measured strata was made. The name "Geddes" was proposed for the bed of flaggy limestone that lay conformably on the top of

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4/ Binyon, E. O., Exploration of the Gold, Silver, Lead, and Zinc Properties, Eureka Corporation, Eureka County, Nev.: Bureau of Mines Rept. of Investigations 3949, 1946, 18 pp.

5/ Hague, Arnold, Abstract of the Report on the Geology of the Eureka District, Nev.: In 3d. Am. Rept., U. S. Geol. Surv., 1881-82, 1833, pp. 237-290. Also, Geology of the Eureka District (Nev.): Geol. Surv. Mono. 20, 1892, 419 pp.

6/ Curtis, J. S., Silver-lead Deposits of Eureka, Nev.: Geol. Surv. Mono. 7, 1884, 200 pp.

7/ Walcott, D. D., Paleontology of Eureka District, Nev.: Geol. Surv. Mono. 8, 1884, 298 pp.

8/ Resser, C. E., Nomenclature of Some Cambrian Trilobites: Smithsonian Misc. Coll., vol. 93, No. 5, 1935, 46 pp.
Second Contribution to Nomenclature of Some Cambrian Trilobites: Smithsonian Misc. Coll., vol. 95, No. 4, 1936, pp. 1-29.
Third Contribution to Nomenclature of Some Cambrian Trilobites: Smithsonian Misc. Coll., vol. 95, No. 22, 1937, pp. 1-29.

9/ Wheeler, Harry E., and Lemmon, Dwight M., Cambrian Formations of the Eureka and Pioche Districts, Nev.: Geol. and Min. Surv. No. 31, vol. 33, No. 3, 1939, pp. 13-32.

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the El Dorado dolomite and of which it was formerly considered a part. It was designated as a separate formation. Faunas were reallocated, which, according to Wheeler and Lemmon, would aid in distinguishing and properly placing the formations in their true sequence and would also lead to a better understanding of certain structural fractures that had been misinterpreted or entirely overlooked.

The oxide and sulfide ore bodies, containing gold, silver, and lead, and gold, silver, lead, zinc, and cadmium, respectively, occur as typical replacement deposits in the El Dorado dolomite, a member of the Paleozoic sediments that are widespread through the Great Basin area. The age of the El Dorado has been designated as of the Lower and Middle Cambrian period of the Paleozoic era.

Some relatively small oxide-ore bodies have been found in the upper beds of dolomite and limestone (the Hamburg and Pogonip). The more important deposits, however, are confined almost entirely to the El Dorado dolomite. This stratum, 2,000 feet thick, is composed of a secondary dolomitic limestone in which dolomite predominates. The color ranges from light gray to black. Bedding has been virtually obliterated by faulting; apparently the entire bed has been crushed and recemented with calcite.

The stratigraphic sequence of Cambrian formation in the district, as determined by Wheeler and Lemmon, is:

"Pogonip" limestone.....	425	Lower portion	)
Dunderburg shale.....	340		)Upper Cambrian
Hamburg dolomite	900		)
Secret Canyon shale	1,035		)Middle Cambrian
Geddes limestone	335		)
El Dorado dolomite	2,000		Middle and Lower Cambrian
	5,035		
Prospect Mountain quartzite.	1,600		Lower Cambrian
	6,635		

Although the total thickness of strata is 6,635, this is not the thickness it will be necessary to penetrate to reach the sulfide deposits, as they were found 500 feet from the top of the El Dorado dolomite. In the fault block under exploration, the following thicknesses are found: Hamburg, 1,035; Secret Canyon shale, 350; Geddes, 0 to 150; and El Dorado, 800. It is presumed that thinning of these beds has resulted from thrust faulting.

The deposits of oxidized ore on Ruby Hill were confined to a segment of the El Dorado dolomite, which apparently is an upthrust fault block on the footwall of the Ruby Hill fault. This fault, with the parallel branches or secondary fissures, is thought to be the main channel for the mineralizing solutions that result from igneous intrusions. Although it is generally accepted that the mineralizing action was of igneous origin and that either the granite, monzonite, or rhyolite found in the area might have been the source of the solution, a definite genesis has not been determined. It is suspected that the Jackson fault may have been the channel through which mineralizing solutions reached the El Dorado dolomite.

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As stated, the deposits are of the replacement type, and, judging from the analyses of the ores from the upper segment, the ascending mineralizing solution completely replaced the El Dorado dolomite. Few, if any, inclusions of unreplaced dolomite were found in the ore deposits. The ore bodies of Ruby Hill seem to have no definite pattern either as to position or size and shape. The physical condition of the dolomite and the main structural features, the Ruby Hill and other faults, are certainly the most important factors in the formation and distribution of the ore bodies. The chemical composition of the rock (that is, whether dolomite or limestone) apparently had little if any bearing on the formation of the ore bodies, as they occurred neither in any particular horizon nor with any definite pattern. No criteria have been found from which either the size or shape, dip or strike, or position of occurrence of ore bodies can be predicted. Dip and strike varied with the individual ore bodies; some were flat and seemed to follow the direction of the thrust faults; others conformed to the strike and dip of the normal faults; still others occurred as isolated bodies with unrelated strike or dip.

Some of the ore bodies were connected by stringers of iron oxide of varying size, and although some relation apparently existed between ore bodies, there was no definite criterion that could be used for locating them. All the upper ore bodies were almost completely oxidized, the oxide zone extending from the surface to 1,200 feet, or slightly below water level.

Results of diamond-drilling by the corporation and the Bureau were exceptionally favorable. All of the underground holes found good thicknesses of sulfide ore and proved beyond doubt that the El Dorado dolomite in the area on the hanging wall of the Ruby Hill fault, lying between Jackson fault on the east and the Bowman on the west, is in its normal position in the stratigraphic sequence, that it is mineralized, and that the manner of occurrence of these sulfide ore bodies is somewhat similar to that of the upper oxide deposits.

Data obtained from core-drill samples through the deposit in the El Dorado dolomite in the hanging wall of the Ruby Hill fault indicate that in this segment of the dolomite replacement action of the solutions was also very complete. The analysis shows an extremely low percentage of insoluble and other gangue material.

Although little is known concerning the lateral extent or the shape of these sulfide deposits, results from the diamond-drill holes seem to point to greater uniformity in the dip and strike and a more definite horizon than was found in the oxidized areas, with perhaps less erratic spacing of the ore bodies. The source of mineralization is the same for both the sulfide and oxide ore bodies. The lower ore bodies are mainly sulfides, with only an oxidized shell. Increase in zinc and decrease in lead contents of the sulfide ore indicate a zonal distribution of these metals.

It has been reported that the outlines of the oxide ore bodies were well-defined - that there was a definite line of demarcation between the ore and barren dolomite. This is true, also, of the sulfide ore bodies. In all the holes drilled by the Bureau and the Corporation there was a sharp break

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between the ore and waste on both the hanging wall and footwall. With the line of demarcation so easily distinguishable, no difficulty whatever should be experienced in determining the limits to which ore can be mined.

PREPARATION PERIOD

The Fad shaft site was selected in an area approximately 1,000 feet northeast of the center of the ore body, as outlined by diamond drilling, and about 2,300 feet north of the Ruby Hill fault. (See figure 3, Plan of proposed 2250 level, and figure 4, Vertical sections of A-A and B-B.)

A factor in delecting the site was that the shaft could be started in semiconsolidated rubble with a minimum of the necessary preparatory work for buildings and headframe. Also, sufficient space was available for dumping material to be excavated from the shaft and other underground workings. Figure 5 is a plan of the Fad shaft lay-out. The surfave geology, which shows the location of three major faults between the shaft site and the ore zones as well as the geologic data on the character and approximate depths of the formations obtained from the drill holes, assisted somewhat in planning sinking operations. With this information available, the approximate location of bad ground as well as probable courses of an increased flow of water were known in advance.

All materials and plant equipment were hauled to Eureka by truck from East Ely, Nev., over U. S. Highway 50, a distance of 80 miles. The mountainous road from Eureka to the shaft site, a distance of 2.5 miles, is in poor condition, the curves are sharp, and in several places the grades are too steep for regular hauling. A new road to the mine is now being constructed.

Proximity to the town of Eureka, Nev., made it unnecessary to construct camps at the property. The following temporary buildings and equipment were used in the preliminary operations:

Temporary Buildings

Building	Size, feet	Type of construction
Office	Old dwelling	Frame: 2x4-inch joists, rafters and studding. Covered with fir and good-quality roofing; finished inside with celotex.
Hoist and compressor house	20 x 20	Wood frame and sheet galvanized-iron cover.
Dry house	12 x 12	Wood frame and sheet galvanized-iron cover.
Blacksmith shop	12 x 12	Wood frame and sheet galvanized-iron cover.
Substation	In hoisthouse	1,500-watt Kohler plant for lights.

The buildings listed above were required in the shaft-sinking operations and were erected as temporary structures only because the company was unable to obtain materials for building on a permanent basis.

In the fall of 1944, the hoist and compressor house, with all equipment, was destroyed by fire.

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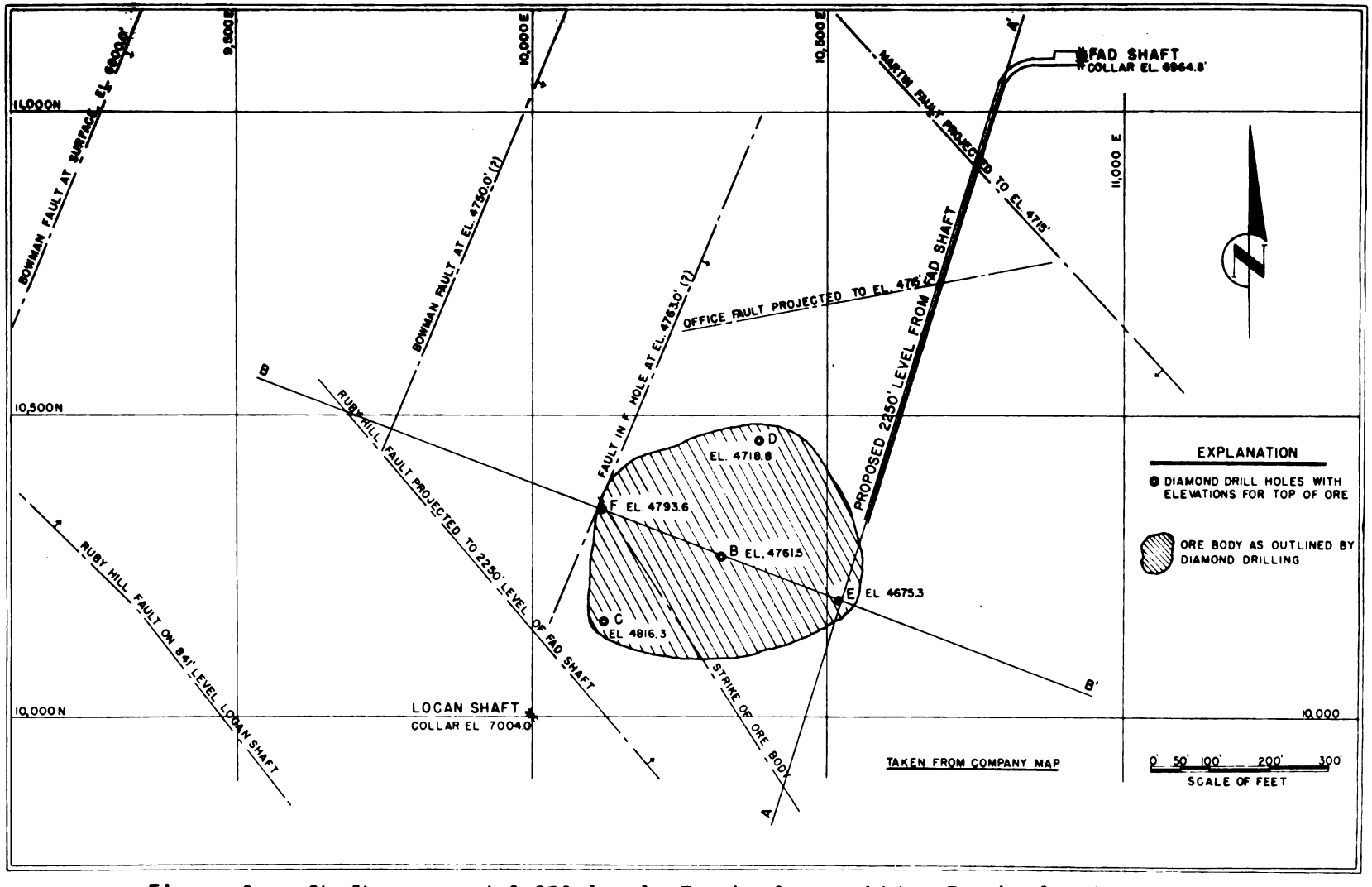

Figure 3. - Shaft proposed 2,250 level, Eureka Corp., Ltd., Eureka County, Nev.

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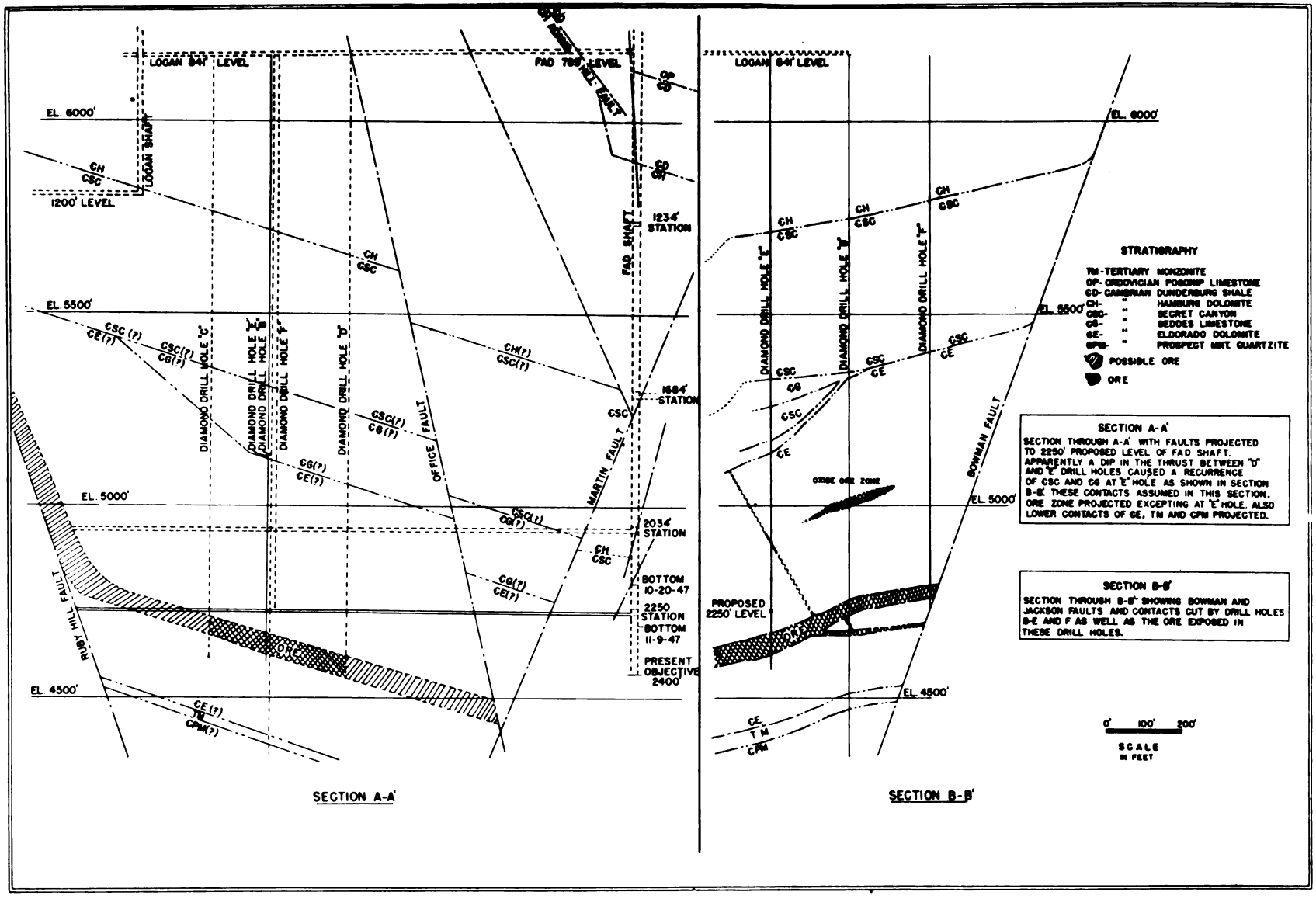
LOGAN 84' LEVEL
FAD 768' HOLE FAULT
LOGAN SHAFT
EL. 6000'
1200' LEVEL
FAD SHAFT
1234' STATION
EL. 5500'
DIAMOND DRILL HOLE "C"
DIAMOND DRILL HOLE "E"
DIAMOND DRILL HOLE "F"
DIAMOND DRILL HOLE "D"
OFFICE FAULT
MARTIN FAULT
1684' STATION
EL. 5000'
2034' STATION
BOTTOM 10-20-47
2250' STATION BOTTOM 11-9-47
PRESENT OBJECTIVE 2400'
RUBY HILL FAULT
ORE
EL. 4500'
SECTION A-A'
DIAMOND DRILL HOLE "B"
DIAMOND DRILL HOLE "A"
BOWMAN FAULT
OXIDE ORE ZONE
PROPOSED 2250' LEVEL
STRATIGRAPHY
TM - TERTIARY MONZONITE
OP - ORDOVICIAN POGONIP LIMESTONE
GD - CAMBRIAN DUNDERBURG SHALE
CH - " HAMBURG DOLOMITE
CSC - " SECRET CANYON
CG - " GEDDES LIMESTONE
CE - " ELDORADO DOLOMITE
CPM - " PROSPECT MNT QUARTZITE
POSSIBLE ORE
ORE
SECTION A-A'
SECTION THROUGH A-A' WITH FAULTS PROJECTED TO 2230' PROPOSED LEVEL OF FAD SHAFT. APPARENTLY A DIP IN THE THRUST BETWEEN "D" AND "E" DRILL HOLES CAUSED A RECURRENCE OF CSC AND CG AT "E" HOLE AS SHOWN IN SECTION B-B'. THESE CONTACTS ASSUMED IN THIS SECTION. ORE ZONE PROJECTED EXCEPTING AT "E" HOLE. ALSO LOWER CONTACTS OF CE, TM AND CPM PROJECTED.
SECTION B-B'
SECTION THROUGH B-B' SHOWING BOWMAN AND JACKSON FAULTS AND CONTACTS CUT BY DRILL HOLES B-E AND F AS WELL AS THE ORE EXPOSED IN THESE DRILL HOLES.
0' 100' 200'
SCALE IN FEET
SECTION B-B'

Figure 4. - Eureka Corp., Ltd., Eureka County, Nev.

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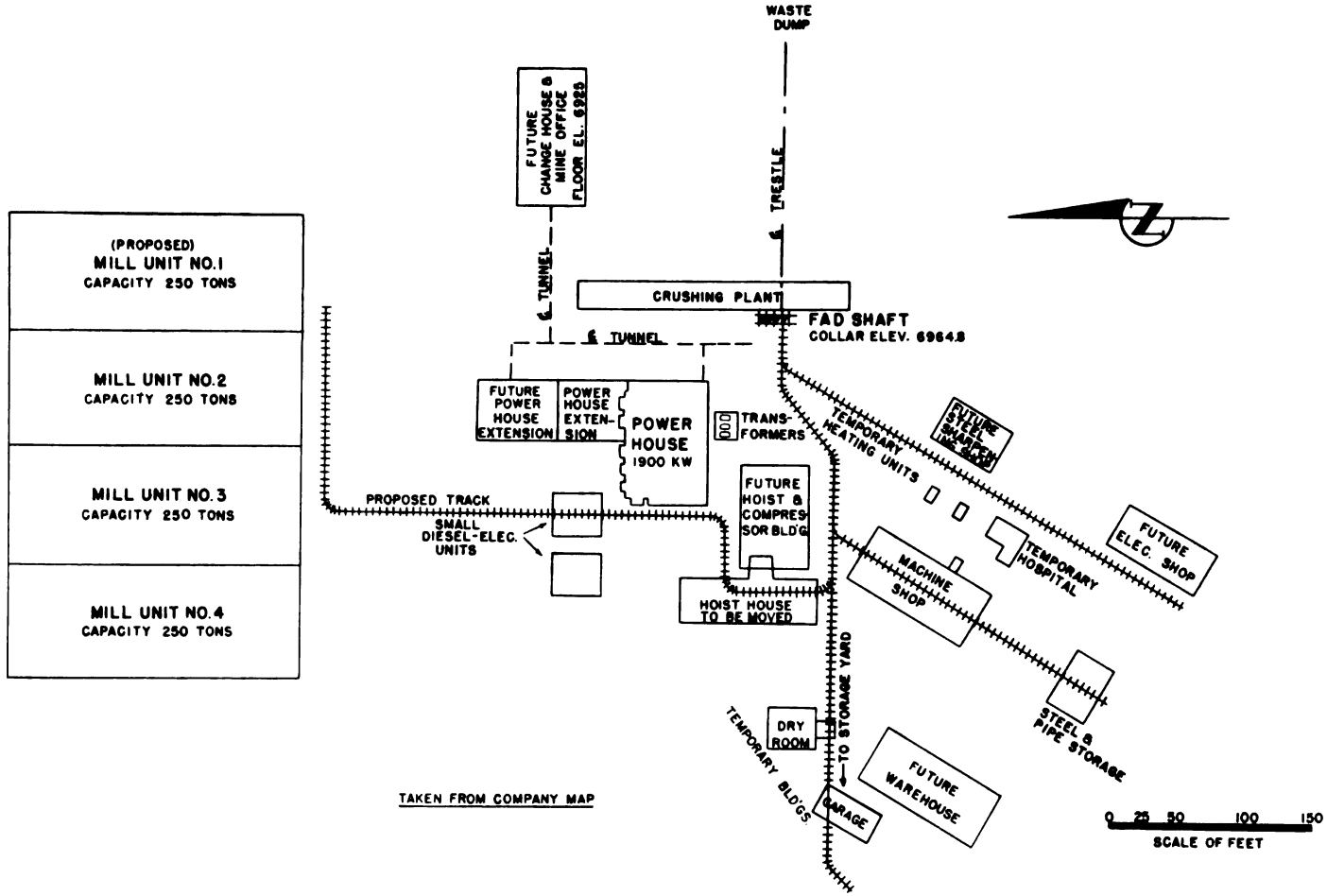

Figure 5. - Fad shaft plant layout, Eureka Corp., Ltd., Eureka County, Nev.

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Permanent Buildings

In February 1945, construction and equipping of permanent buildings was started. To date, the following buildings have been built and permanent equipment installed:

Building	Size, feet	Type of construction
Office	Old dwelling	Frame: 2x4-inch joists, rafters, and studding. Covered with fir and good-grade roofing; finished inside with celotex.
Dry house	30 x 40	Wood frame, sheath covered with corrugated aluminum and lined with celotex.
Hoist and compressor house	100 x 30	Wood, sheathing and covered with galvanized iron.
Machine and blacksmith shop	45 x 100	Wood, sheathing and covered with galvanized iron.
Topmans house	6 x 10	Frame.
Power house	45 x 100	Wood frame, wood sheathing covered with galvanized iron.
Substation 3 banks of 375-kv.-a. transformers used for stepping-up 480 volts to 2,400 volts	30 x 30	All metal (galvanized) on a concrete base.
Powder magazine		Standard wood frame, wood-sheathed inside and out, with 6-inch studs filled with sand.
Automotive storage	50 x 20	Standard wood frame, wood-sheathed and covered with galvanized iron.
Emergency first-aid station	20 x 36	Wood frame, wood sheathing, insulated between walls and ceiling.

Cost of Mine Buildings

Office	$5,000
Dry house	9,000
Hoist and compressor house	7,500
Machine and blacksmith shop	20,000
Topmans house	500
Power house	100,000
Substation	5,000
Powder magazine	3,000
Automotive storage	3,000
Emergency first-aid station	3,000
Total	156,000

The total cost of the structures listed is not strictly chargeable to shaft sinking. Although they are required in sinking the shaft, they were designed to serve during later underground exploration and development. The same is true of larger items of equipment costs listed in the next section of this paper.

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SURFACE PLANT

Principal plant items consist of electrically driven hoists and compressor, transformer and substation equipment, machine and blacksmith shop equipment, surface pipe lines, water-purifying system, steel racks, pumps and heating system, emergency first-aid station, power plant and substation housing three banks of 375-kv.-a. transformers used in stepping-up 480 volts to 2,400 volts, and the 60-foot, steel, head frame.

The main hoist is a 74- by 60-inch, double-drum, electric hoist having a capacity of 14,000 pounds on a single line at a speed of 1,200 feet per minute and is powered by two 300-horsepower, 2,300-volt, 3-phase, 60-cycle, slip-ring motors. It is equipped with two Lilly hoist controllers and two oil-operated brakes, position indicators, etc.

The auxiliary or chippy hoist (J. George Leyner) is a single-drum, 42x24-inch, double-reduction gear driven by a 50-horsepower, 440-volt, 3-phase, 60-cycle, squirrel-cage motor with a rope speed of 250 feet per minute.

The cable on the main hoist is a 1-inch-diameter, 18x7 strand pre-formed, regular-lay, nonspin, improved, plow-steel cable.

The cable used on the auxiliary hoist is a 5/8-inch, 6/19, pre-formed, Langlay, improved, plow-steel hoisting cable. The air compressors deliver approximately 2,000 cubic feet of free air per minute at 100 pounds. The four units are as follows:

2 Ingersoll Rand Imperial Type No. 10:
  1 delivers 450 cu. ft./m. 100 h.p.
  1 delivers 900 cu. ft./m. 200 h.p.
1 Chicago-pneumatic delivers 350 cu. ft./m. 100 h.p.
1 Sullivan delivers 350 cu.ft./m. 75 h.p.

A 60-foot steel headframe has been erected over the four-compartment shaft. There are two 5-foot head sheaves on the two hoisting compartments. These compartments are equipped with the necessary safety doors and chutes for dumping the sinking buckets. The pump and pipe compartment is equipped with a 3-foot sheave, dump doors, etc.

The power plant that furnishes power for the Eureka Corp. mine is housed in a well-constructed 45- by 90-foot building. It is framed of 8- by 8-inch timber, and the columns are designed to support the roof and crane load. The siding consists of 1-inch shiplap, building paper, and galvanized corrugated iron. The roof is covered with 2-inch T & G diagonal sheathing, roofing paper, and galvanized corrugated iron. Metal sash are used on all the buildings, with extra-heavy wire-reinforced glass.

The full basement keeps the main floor free of piping and electrical equipment and is also used as storage space for spare parts.

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The floor is designed to accommodate a live load of 20,000 p.s. ft., so that any part of the heavy generating unit can be shifted in installing and maintenance work without danger of its collapsing.

The color scheme of the attractive interior is a bone-white ceiling, focal green walls, and pearl-gray floor. All paint used on woodwork is fire-retarding.

The power units are a lustreless green. The contrasting orange of the railings and operating switches is used for safety.

The building is designed to provide ample room for efficient operation and maintenance. A 5-ton traveling crane has been installed to facilitate maintenance.

With the beginning of large-scale operations in 1945, the three 375-kv.-a. units were installed. These generators are powered by 480-horsepower McIntosh Seymour Diesels, which are cooled by Buffalo Forge evaporative coolers. All auxiliary units are operated through a central motor control, with push buttons at each unit.

These 480-volt, 3-phase, 60-cycle generators are synchronized into a common bus through a standard switchboard. Incorporated with this switchboard are the distribution panels for the 480-volt power. The bus is connected to a bank of transformers to step-up the voltage to 2,300 for line distribution.

In 1946, preparations were made for the installation of a 1,250-kv.-a. unit and were completed in the spring of 1947. The power characteristics of this G. E. generator are 2,300-volt, 3-phase, and 60-cycle. It is powered by a Worthington Model SEH-8 Turbo supercharged Diesel engine. This, too, is cooled by evaporative coolers, and the auxiliary units are operated through the central motor control.

A 2,300-volt bus, oil switch for the generator panel, and the oil breakers for the distribution panels are in a fireproof room in the basement and are operated from the main floor by 220-volt central switches. The 2,300-volt generator is synchronized with the 480-volt units through the aforementioned transformers. These transformers are now used to step up or step down the voltage. Both 480-volt and 2,300-volt switchboards are equipped with totaling watt-hour meters, recording wattmeters, and recording voltmeters to give a true picture of the performance of these units, which operate with a power factor of 0.85 percent. The operating costs for 1946 averaged 2.54 cents per kw.-hr. and to date this year 2.1 cents per kw.-hr. The lowest cost per month was in July 1947 - 1.35 cents per kw.-hr. The above costs do not include amortization of the plant investment.

A water-treatment plant has been installed, and part of the water from the shaft is run through the plant to be filtered, softened, chlorinated, and pumped into a 50,000-gallon steel tower on 50-foot legs.

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Hospital

A 3-room, 2-bed receiving hospital has been erected near the shaft, which is equipped for emergency operations and also to take care of patients over a considerable length of time if necessary.

Surface Plant Equipment Costs

The following figures cover the cost of plant equipment, including freight and haulage and the cost of installation:

Equipment	Cost
Office equipment	$2,000
Hoist and installation, except foundation	55,000
Chippy hoist and installation, except foundation	6,000
Hoist foundations	6,000
Headframe	10,000
Compressors and installations, except foundations	30,000
Compressor foundations	3,000
3 McIntosh-Seymour Diesel units direct-connected to 300-kw. generators[1/]	75,000
Switchboard and other control auxiliaries, Diesel unit	5,000
1 direct-connected, 1,000-kw. generator	115,000
Foundations for power units	10,000
Machine and blacksmith shop equipment:	
1 18-inch, 10-foot bed lathe	2,000
1 high-speed cutting wheel	500
1 small planer	1,200
1 small power-driven press	500
1 radial drill press	1,000
1 power hacksaw	250
1 stationary pipe threader	500
1 set of metal rolls	250
3 electric welders	1,800
6 acetylene welding outfits	800
1 power hammer, Ingersoll Rand	200
1 forge	300
Dry house equipment	2,000
Substation equipment	2,000
Cap house	500
Water-supply system	10,000
Miscellaneous surface equipment Surface trucks	15,000
Surface pipe lines	10,000
Surface pumps and motors Heating system	8,000
	373,800

1/ Transformers included with McIntosh engines.

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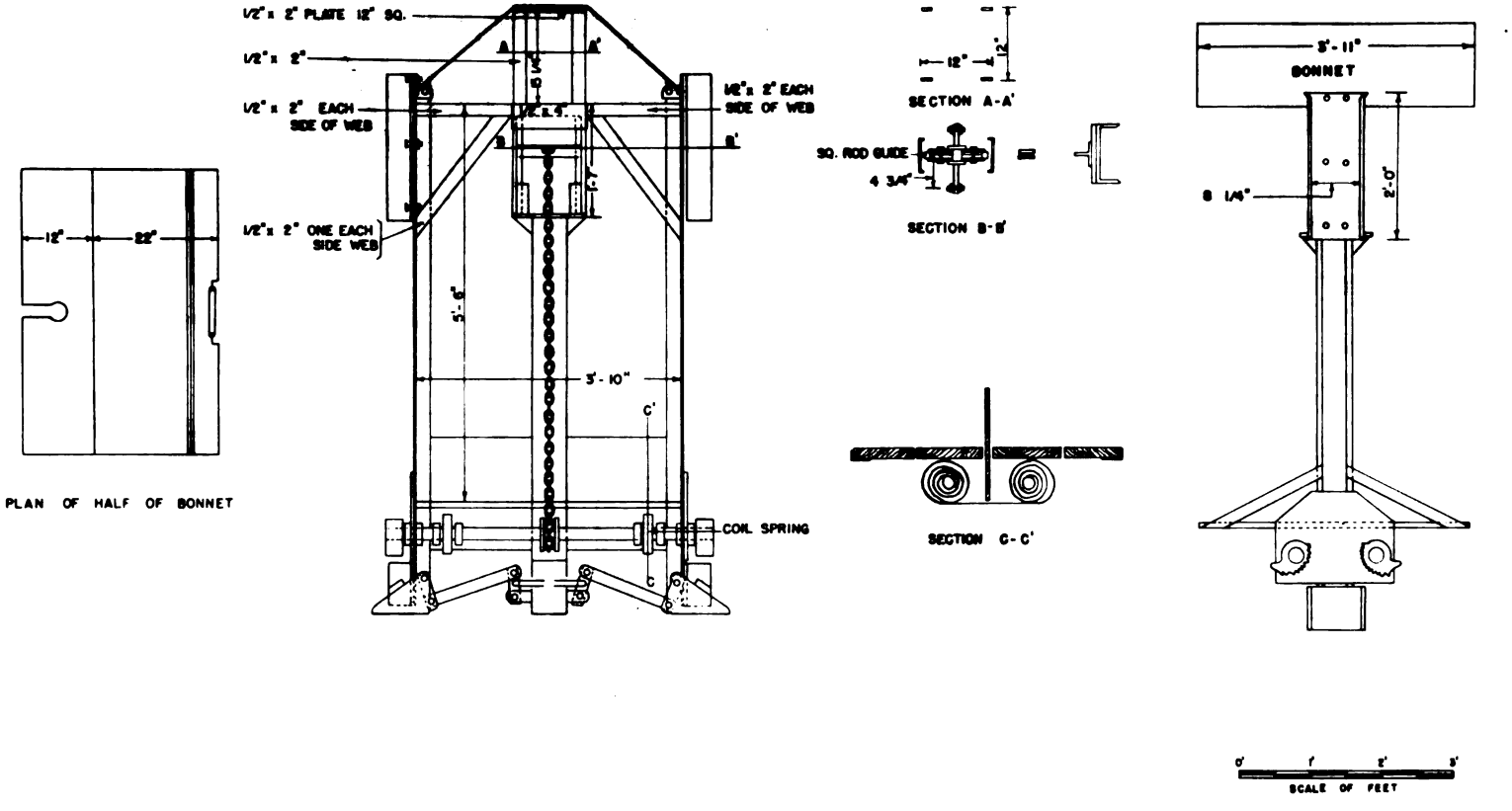

Figure 6. - Fad shaft, safety cross head, for Eureka Corp., Ltd., Eureka, Nev.

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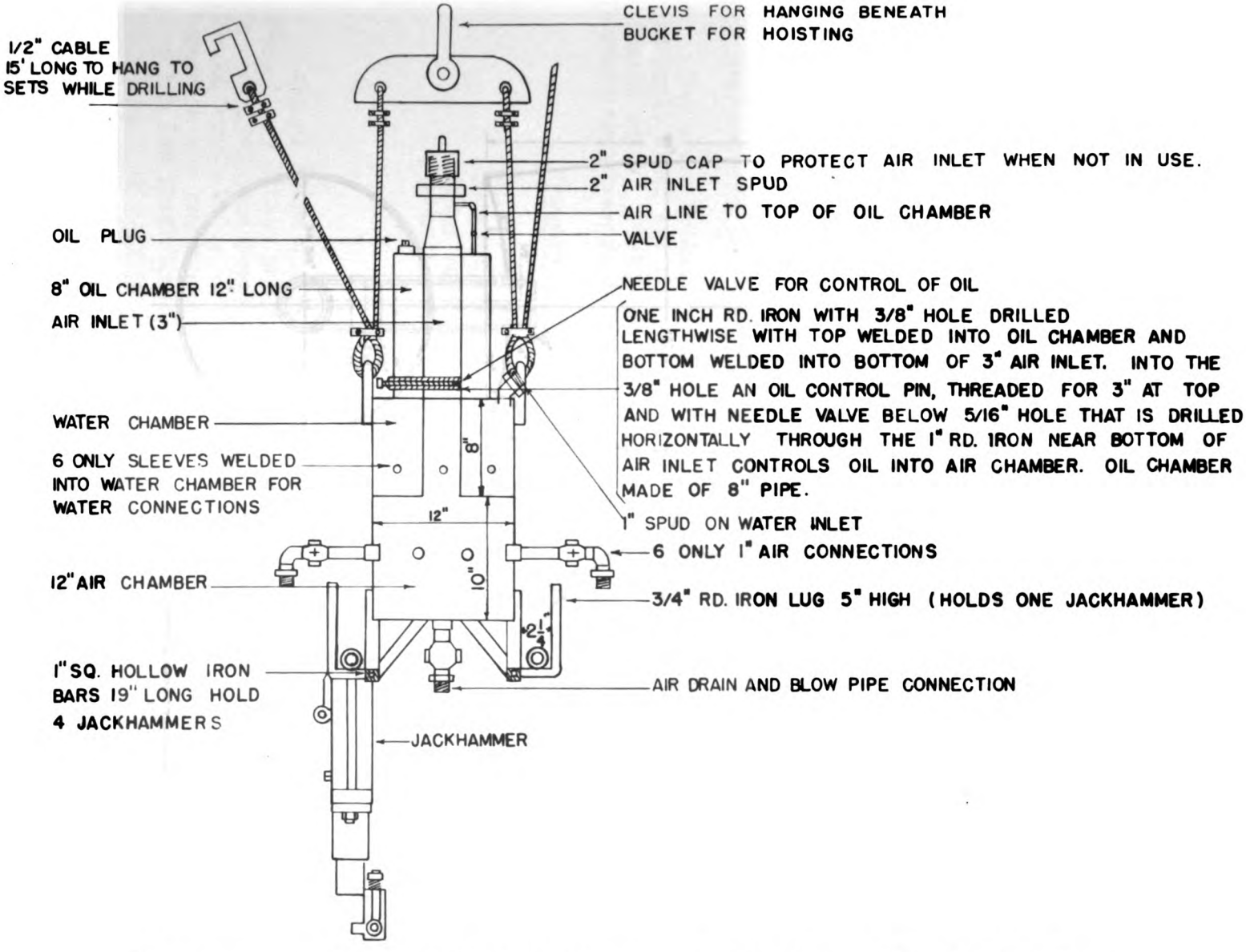
CLEVIS FOR HANGING BENEATH
BUCKET FOR HOISTING
1/2" CABLE
15' LONG TO HANG TO
SETS WHILE DRILLING
2" SPUD CAP TO PROTECT AIR INLET WHEN NOT IN USE.
2" AIR INLET SPUD
AIR LINE TO TOP OF OIL CHAMBER
VALVE
OIL PLUG
8" OIL CHAMBER 12" LONG
AIR INLET (3")
NEEDLE VALVE FOR CONTROL OF OIL
ONE INCH RD. IRON WITH 3/8" HOLE DRILLED
LENGTHWISE WITH TOP WELDED INTO OIL CHAMBER AND
BOTTOM WELDED INTO BOTTOM OF 3" AIR INLET. INTO THE
3/8" HOLE AN OIL CONTROL PIN, THREADED FOR 3" AT TOP
AND WITH NEEDLE VALVE BELOW 5/16" HOLE THAT IS DRILLED
HORIZONTALLY THROUGH THE 1" RD. IRON NEAR BOTTOM OF
AIR INLET CONTROLS OIL INTO AIR CHAMBER. OIL CHAMBER
MADE OF 8" PIPE.
WATER CHAMBER
6 ONLY SLEEVES WELDED
INTO WATER CHAMBER FOR
WATER CONNECTIONS
8"
12"
1" SPUD ON WATER INLET
6 ONLY 1" AIR CONNECTIONS
12" AIR CHAMBER
10"
3/4" RD. IRON LUG 5" HIGH (HOLDS ONE JACKHAMMER)
2 1/4"
1" SQ. HOLLOW IRON
BARS 19" LONG HOLD
4 JACKHAMMERS
AIR DRAIN AND BLOW PIPE CONNECTION
JACKHAMMER

Figure 7. - Shaft header for 6 jackhammers, Eureka Corp., Ltd., Eureka, Nev.

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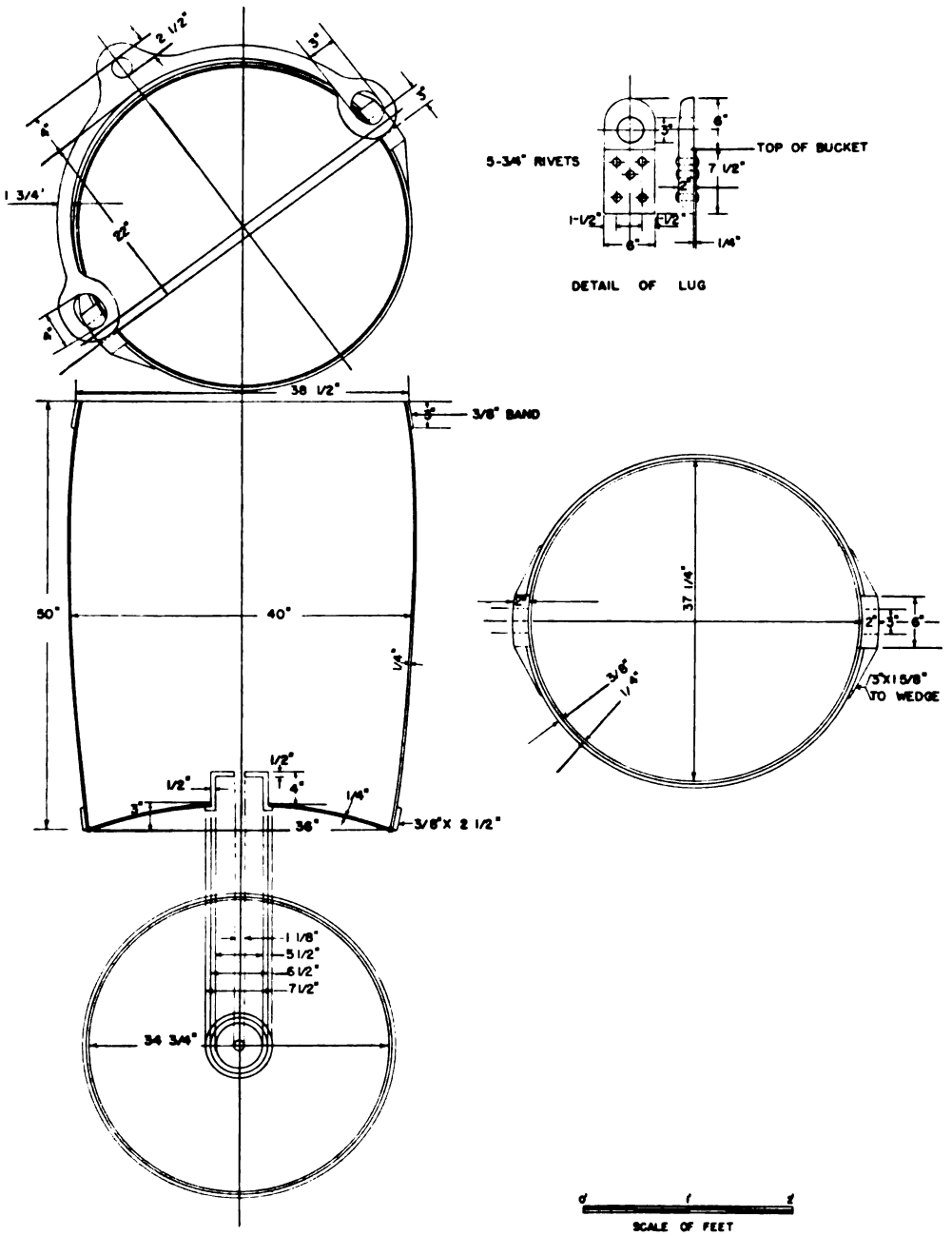

Figure 8. - Shaft bucket for Fad shaft, Eureka Corp., Ltd., Eureka, Nev.

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Underground Equipment and Cost

Sinking equipment consisted of the usual rock drills, hose and accessories, shaft header for 6 jackhammers, sinking buckets, cross head, pumps, signaling system, and small tools. The cross heads were of special construction and were well-designed. The construction is shown in figure 6.

The cost of underground equipment is itemized as follows:

Rock drills:	
10 jackhammers	$2,850
5 drifters	4,010
Underground pumps and motors:	
9 station pumps	63,000
6 sinkers	21,000
3-drum slusher hoist on dump	5,000
2 safety cross heads	1,000
1 scraper on dump	1,000
3 30-cu. ft. sinking buckets	3,000
15,000 feet 3/0 armored cable (power down shaft)	45,000
	145,860

The cross heads, shaft header, blasting set, hoisting signals, mine tools, and drill steel are written into the operating costs and are included in the sinking costs. Design of the shaft header for 6 jackhammers and the sinking buckets are shown on figures 7 and 8, respectively.

Summary of Preparation, Plant, and Equipment Costs

Mine road and clearing site	$25,000
Buildings (not including head frame)	156,000
Plant equipment, including head frame	373,800
Underground equipment	160,000
	714,800

SHAFT SINKING

Actual shaft sinking was begun late in 1940 and continued until October 1943. Very little progress was made in 1943 owing to lack of equipment. In October 1943, the Bureau of Mines diamond-drilling program was begun. The Eureka Corp., Ltd., stopped operations at the Fad shaft and assisted the Bureau in the preparatory work by lending their shaft equipment and moving it from the Fad shaft to the Locan shaft and setting it up.

Following the completion of the Bureau's drilling program, large-scale shaft-sinking operations were begun.

The shaft is 9 by 24 feet, rock dimensions, and is timbered with 6- by 6-inch, 20-pound, steel sets. The shaft is divided into two hoisting compartments and one pump and pipe compartment, which are 5 feet 6 inches by 5 feet in the clear, and one manway compartment 5 feet 6 inches by 4 feet 9

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inches in the clear. (See fig. 9.) Sets are spaced on 6-foot centers, and bearing sets are installed 100 feet apart, or one above and one below the level stations. Concrete rings have been installed where any large water-course has been cut; however, a water ring is seldom installed unless it will serve a double purpose - as a bearing set and to catch water.

The manway compartment has steel grid landings spaced 12 feet apart. The ladders are 16 feet long and are made of 2 by 2 angle irons, and all rungs are reinforcing steel welded to the angle irons spaced 12 inches apart.

Pipe lines consist of a 4-inch air line, two 10-inch pump discharge columns, a 2-inch water line to supply the rock drills, and a 6-inch line for passing concrete, 18-inch ventilating pipe with slip joints, and at 100-foot intervals standard victualic joint is spiral-welded, hot-tar-dipped, 12-gage steel. Tees have been inserted in all pipe lines opposite the various levels to provide connections for later crosscutting and drifting. All pipes used have victualic couplings.

Ventilation

A No. 9 vent air fan made by Coppus Engineering Co. and driven by a 15-horsepower, 440-volt, A-C motor is used for ventilation. It is installed at the collar and can be used to blow or exhaust through the 18-inch ventilating column as required.

Ventilation is good, and it is possible for the men to return to work 15 minutes after blasting.

Sinking Practice

During the first sinking period, from 1940 to 1943, the shaft was sunk to a depth of 556 feet. The equipment used consisted of a 30-foot wooden head frame, a small Diesel hoist, and a compressor that had been used at the Locan shaft. The shaft had only a small flow of water that had been handled by a compressed air-driven sinking pump.

When permanent equipment became available, a concrete collar 30 feet high, extending from semiconsolidated rubble to approximately 15 feet above the original surface was installed for the 60-foot steel headframe for the shaft. This placed the collar at a level established for the plant buildings.

After installation of the new hoist and headframe, sinking operations are carried on regularly on three shifts of 8 hours each, 7 days per week. Each shift on the bottom consists of seven miners, one of whom acts as shift leader, and all shifts work under the direction of the mine superintendent. A deckman is employed at the shaft collar on each shift. Two shaft men work in the Chippy compartment doing work above the bottom, handling pumps, etc.

Two hoistmen on each of the shifts operate the two hoists and look after the air compressors.

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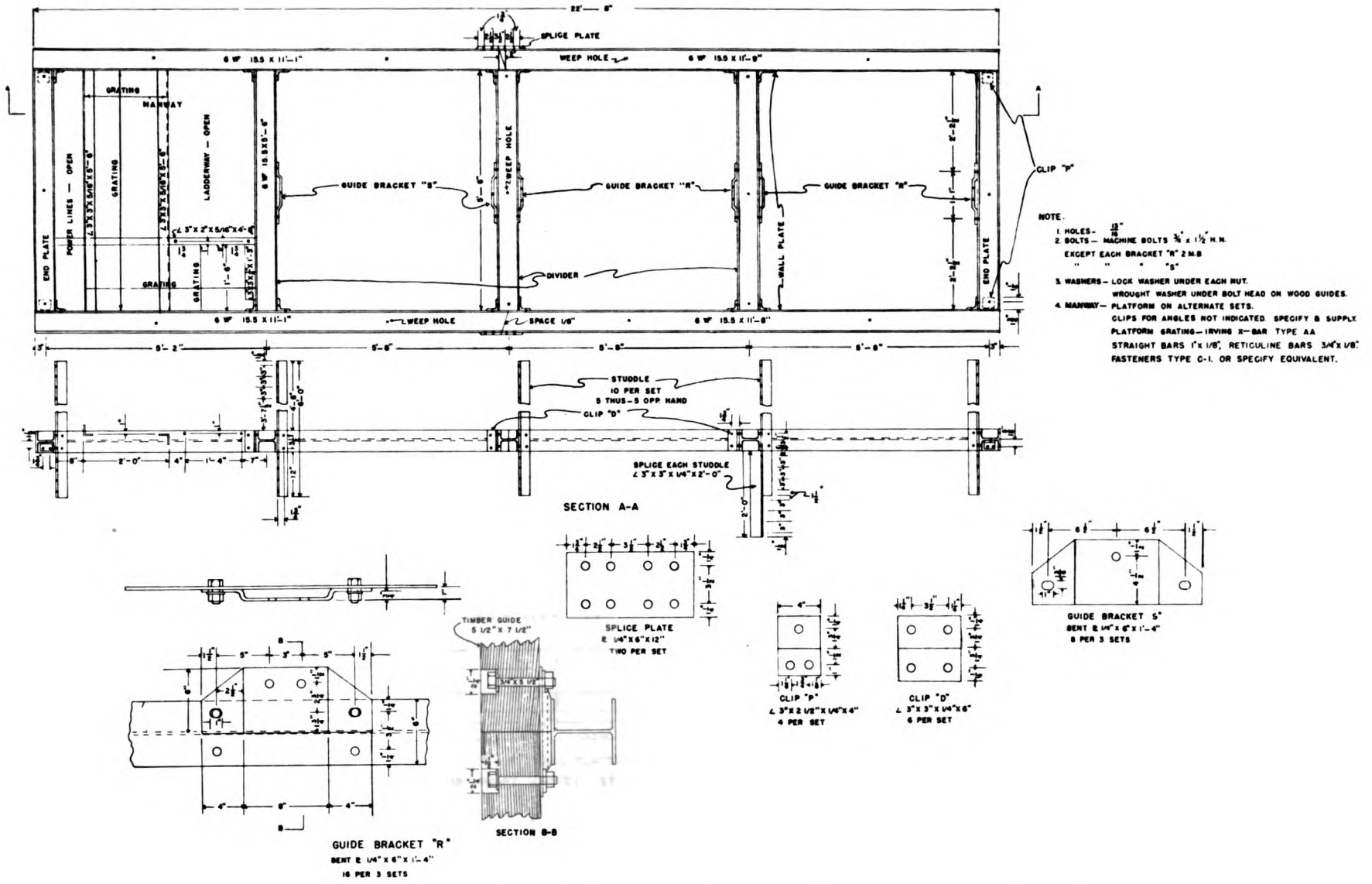

Figure 9. - Steel set for Fad shaft, Eureka Corp., Ltd., Eureka, Nev.

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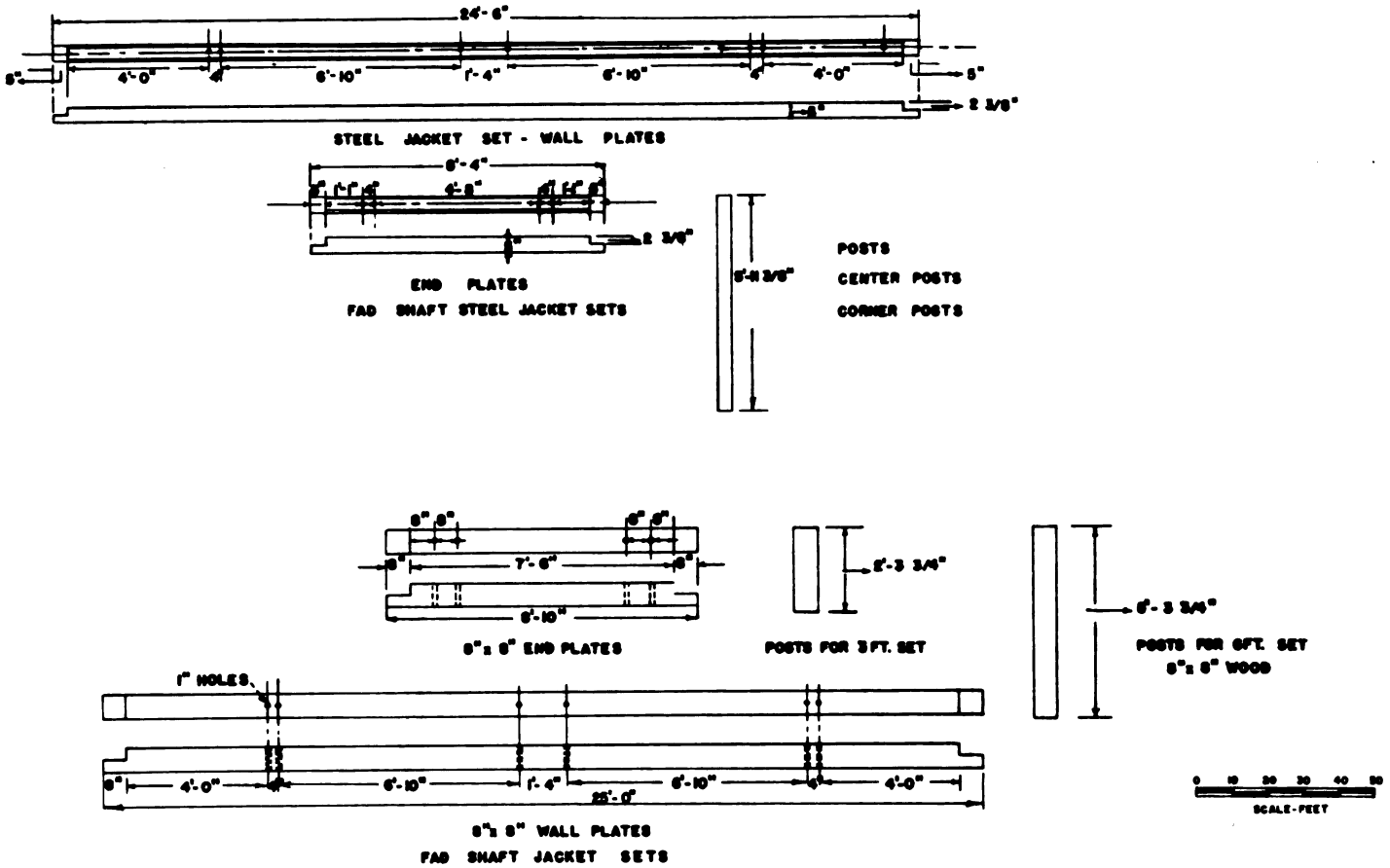

Figure 10. - Fad shaft, jacket sets, Eureka Corp., Ltd., Eureka County, Nev.

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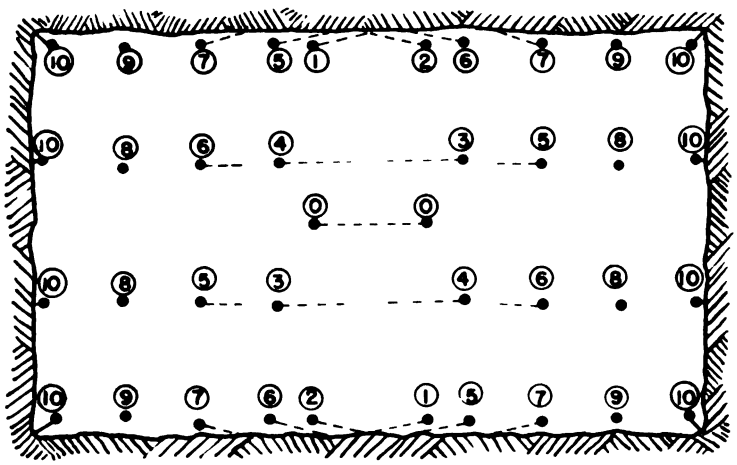

NOTE: THE NUMBER OF THE DELAY DETONATOR USED IN EACH HOLE IS SHOWN ENCIRCLED.

PLAN

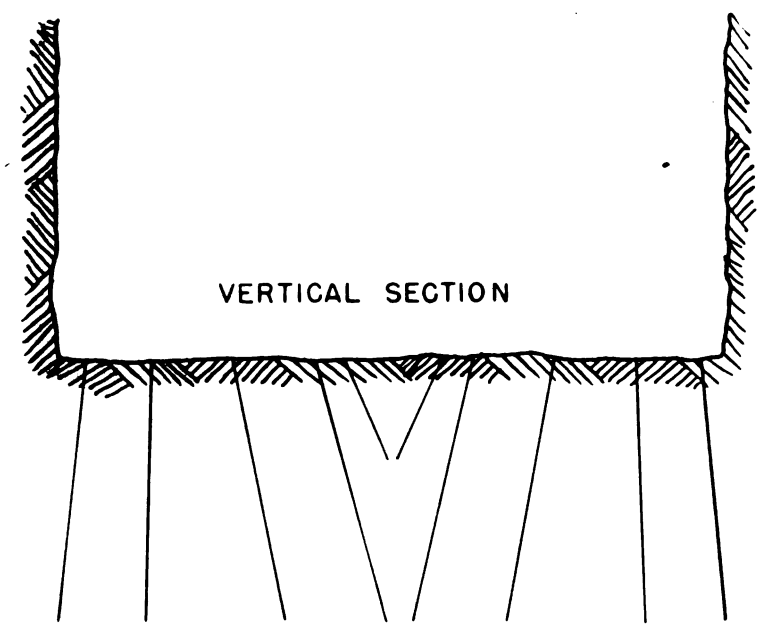

Figure 11. - Shaft round, Fad shaft.

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The shop crew consists of 15 mechanics and a motor mechanic. Six electricians and helpers are employed. The bull gang and carpenters crew consists of 30 men. Some of these men are on construction.

An accountant, two girls working part time, warehouseman, and warehouse attendant are in charge of the stores, timekeeping, and other office work, and also keep the company accounts.

CYCLE OF OPERATION

As already stated, the shaft crew is composed entirely of miners - that is, men competent to perform any of the work in the shaft. Each shift, therefore, simply carries on the work from the point where the preceding shift leaves off, whether that work is drilling, mucking, or timbering. Drilling, mucking, and timbering are done as required. Jacket sets are placed below the steel shaft sets as soon as the round has been mucked down sufficiently to make room for the timbers. (See fig. 10.) Steel sets are placed as often as required, 20 to 25 feet being left between the last steel set and the bottom for the mucking machine.

Drilling

The type of round found to be most efficient in breaking the ground is shown in figure 11. An average of 45 holes are drilled per round, 20 of which are cut holes and 25 of which are square-up holes. With six men in the shaft using four drills, the average drilling time, including time consumed in taking down drills, gear, and steel, is 3 to 5 hours. Five drill machines are taken down to provide a spare machine in case of breakdown. These machines are 2-3/4-inch sinkers equipped with plugger handles. After each drilling, the machines are inspected and serviced. Any broken parts are replaced immediately, and the machines are put in first-class condition for drilling the next round.

Drill steel used is quarter-octagon section with standard detachable bits. Four 2-foot steel changes per hole are made on the cut holes, and three changes are made in the square-up holes. The changes and bit gages are as follows:

Changes	Length, feet	Gage, inches	
Starters	3	2-1/8	2-inch collar pipe
Seconds	5	1-3/4	
Thirds	7	1-5/8	
Fourths	9	1-1/2	

An average of 25 Ingersoll Rand jack bits are used per round.

Drills, steel, scaling bars, and tools are lowered and hoisted in one of the sinking buckets.

Wet drilling is practiced throughout the operation. Air at the machines is maintained as nearly as possible at 100 pounds. Air and water are supplied to the rock drills through a header. Between drilling periods the header is landed on the station above the drilling.

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Blasting

Forty-percent gelatin dynamite is used. The cartridges used are 1-1/8 by 8 inches. All blasting is done electrically from a 220-volt circuit.

Delay-action all-metal detonators (0 to 10 delay) are used and are fired from an electric switch from the level just above the bottom of the shaft. A Tyrex 2-conductor cable is run from the switch to the bottom of the shaft. The holes, with the priming cartridge placed about halfway down, are connected in series with No. 20 insulated connecting wire. The detonators are entirely waterproof, and no trouble has been experienced from short circuits or misfires. The blasting circuit is closed by a switch having a special connector that can be inserted only after the switch box is unlocked. Each shift leader carries a key and is responsible for the blasting.

Mucking

Mucking is done by the Ridell shaft mucker, which is a four-wheeled carriage that travels lengthwise of the shaft on two heavy steel rails suspended from the first shaft set above the bottom of the shaft. The general features of the mechanism are shown in figure 12. The mechanized mucking unit consists essentially of (1) a carriage, A, (2) a frame, B, and (3) a clamshell, C.

Mounted on the carriage are three Ingersoll-Rand compressed air-driven motors. D and E are single-drum, compressed air-actuated motors for the operation of the clamshell bucket, one serving the digging line and the other the hoisting line. Motor F, reversible-geared, is the unit that actuates the movement of the carriage by means of chain drive and sprocket wheels.

Suitable piping, fitted with airline lubricators, all of which are attached to the carriage, serve to feed compressed air to the motors. From the end of the pipe line a rubber hose 1-1/2 inches in diameter and of suitable length, connects to the main header.

Fastened to the carriage are rail guards, which prevent derailment. Two men ride the carriage. One operates the clamshell and the other operates the carriage. The bell signal line to the hoist engineer is cared for by one of the men at the bottom of the shaft. The mucking machine is also set up for single-man operation at the Fad shaft. The frame, B, is made of 112-pound, standard, "heavy," rail section. The rails are placed outside of the shaft sets in the Fad shaft. Attached to the corners of the frame are four hanging rods, K, which, in turn, are bolted to U-shaped hangers, L, which straddle the end pieces of the shaft sets.

When it is necessary to lower the frame and carriage to a new position, the following procedure is followed: First, the clamshell is placed on the bottom of the shaft. Then, the carriage is placed and locked at the center of gravity of the combined carriage and frame. Four clevises, with wire rope and hook attachments, are then fastened to the frame at points near the four corners of the carriage; the hooks are then attached to the rim of the muck bucket, which serves the center compartment of the shaft. The hoist engineer

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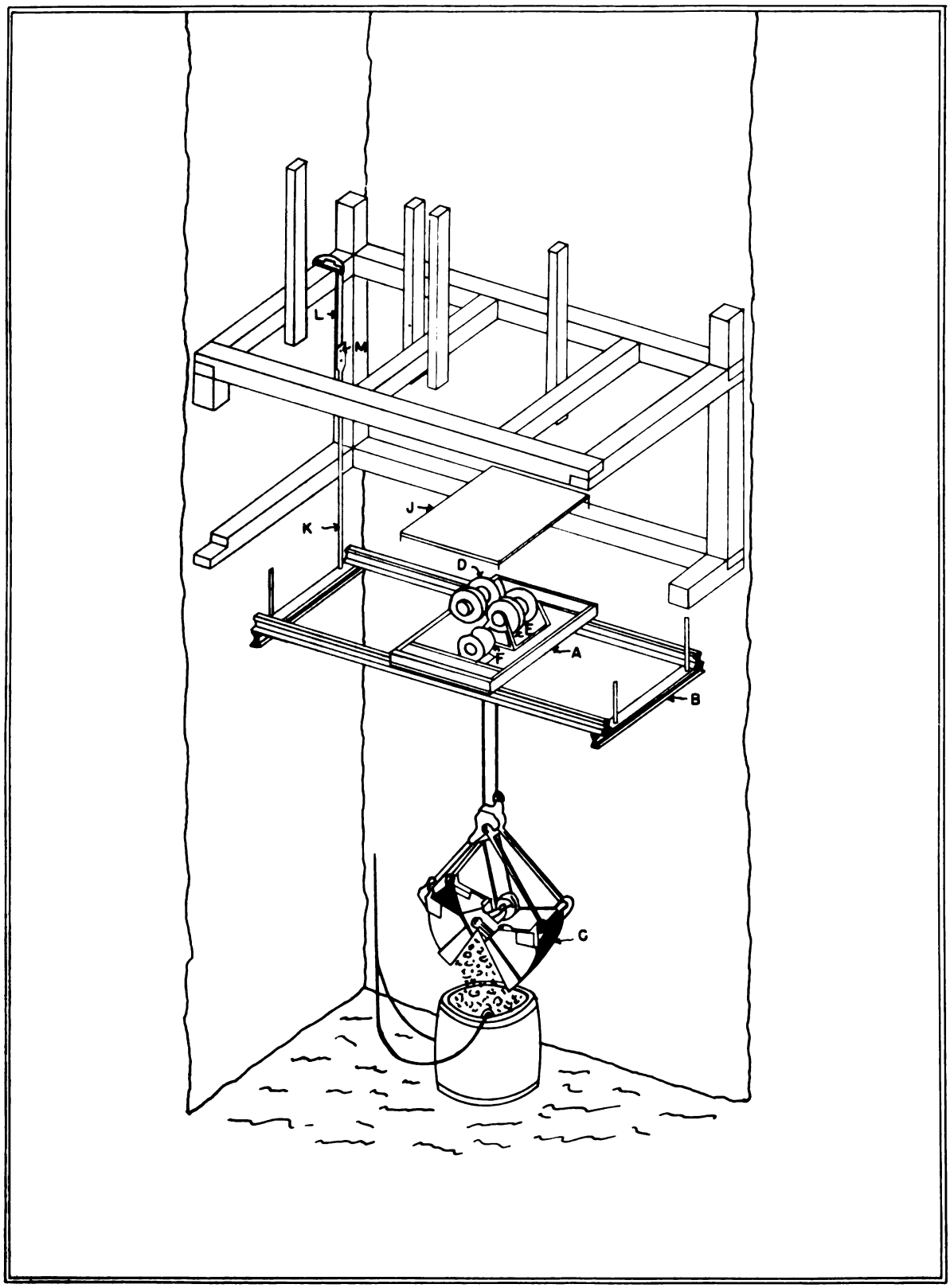

Figure 12. - Riddell shaft mucker, Eureka Corp., Ltd., Eureka, Nev.

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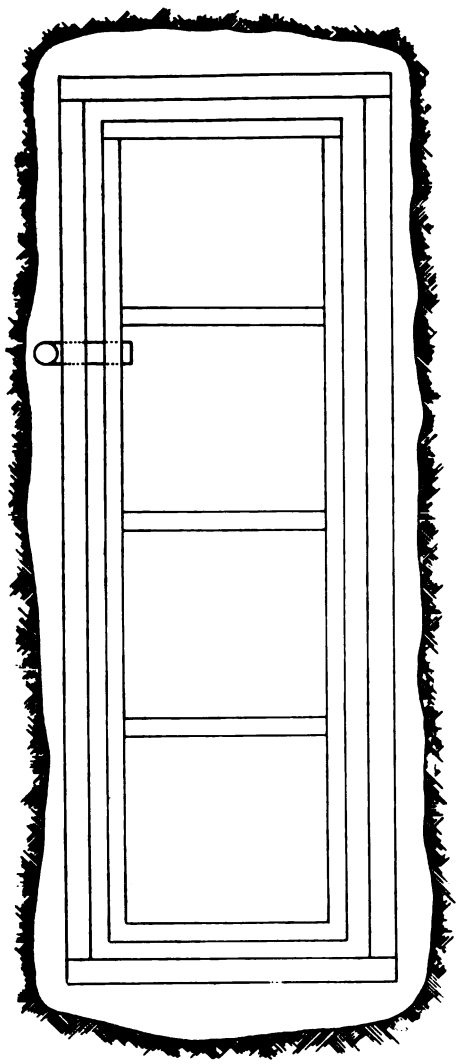

PLAN OF FAD SHAFT WITH JACKET SET

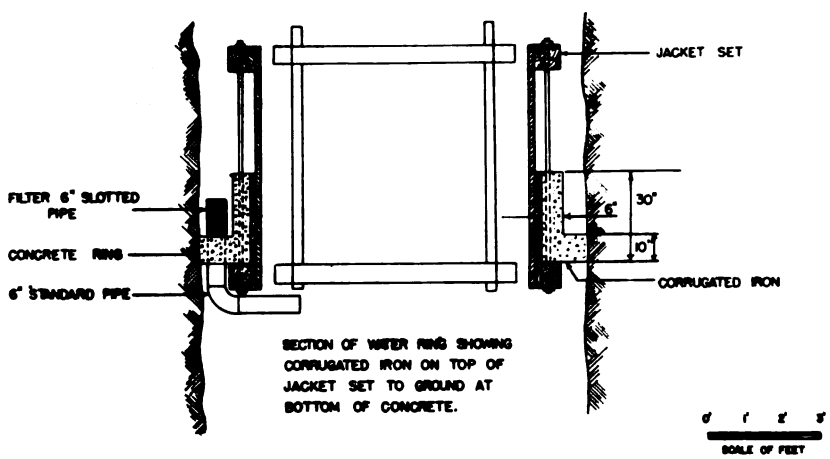

Figure 13. - Fad shaft with jacket set and concrete water ring, Eureka Corp., Ltd., Eureka, Nev.

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is then signaled to "make taut" the hoisting rope and raise the apparatus just enough to turn the U-shaped hangers and hanging rods halfway around. Subsequently, the hoist engineer is signaled to lower one end of the frame and carriage to approximately 1 foot above the next working level while the other end is lowered by a chain block. The U-shaped hangers are then turned to their original position, and the frame and carriage are then lowered to the desired new working position. A 6-inch by 10-inch timber 5 feet in length is then placed across the tops of the U-shaped hangers at both ends of the shaft. Chains are fastened and securely wedged over these timbers and around the end pieces of the shaft set. This is done to prevent the impact of blasting from lifting the frame and unhooking the hangers. Safety chains are placed around the frame of the machine and end pieces of the shaft to prevent the machine from falling should a hanging rod break while the machine is in operation. The required time for changing positions is approximately 12 minutes.

The "hard-digging" clamshell bucket used was made by the Blaw-Knox Co. It is equipped with front, side, and corner teeth, and its capacity is 3/8 cubic yard; width, 20 inches; length, open, 6 feet; and weight, 2,020 pounds.

The 1-1/2-inch diameter air hose, which serves to operate the motors, can also be used in drilling by attaching it to a manifold.

Timbering

The shaft sets are 6- by 6-inch, 20-pound, wide-flange beam with 8- by 8-inch timber jacket sets, with a clearance of 4 inches all around. As the Riddell mucker operates more efficiently in head room of 30 feet from collar of round to the first shaft set from the bottom, the jacket sets are carried normally on 6-foot centers 18 to 24 feet ahead of the shaft sets; occasionally, when ground is heavy, they are carried on 3-foot center and closer to the bottom. Timbering normally follows a blast. Pumps are lowered, and while water is being lowered, the shaft is being blocked and lined. This operation consumes 2 to 3 hours. Following this, 5 to 20 buckets of waste are mucked to make room for a jacket set, which is then hung and blocked and "loose" caught. If ground is short and tends to dribble, 11-gage chain-mesh fencing is placed around the shaft and blocked tight against the ground. Installation of a jacket set requires approximately 1-1/2 hours.

Water

At a depth of 1,380 feet, a heavy flow of water was encountered in the shaft, which delayed shaft-sinking operations for about 3 weeks.

Pumping

The main flow of water in the shaft came from water courses in the dolomite. Concrete rings were planned where any large watercourses were encountered. An effort was made to place the concrete rings for the dual purpose of catching water and serving as auxiliary. Design of the ring is shown in figure 13.

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Permanent pump stations have been cut. The first of these is on the second level, 800 feet below the collar of the shaft, where three 350-horsepower permanent station pumps have been installed. Figure 14 shows the design of a station set. The sump on this level has a capacity of 110,000 gallons of water. The second permanent pump station is on the fourth level, or 1,684 feet below the collar of the shaft, where three more 350-horsepower station pumps are installed. The sump on this station has a capacity of 130,000 gallons of water. (See fig. 15.) The third permanent pump station, to accommodate 3 pumps, is being cut on the sixth level, 2,250 feet below the collar of the shaft.

All of the permanent pumps are identical Ingersoll Rand, 4 G. T., 2-stage pumps with a rated capacity of 1,000 gallons of water per minute against a 950-foot head. They are driven by 350-horsepower, 3-phase, 60-cycle, 2,300-volt motors driven at 3,500 r.p.m.

Pomona pumps are used in the bottom of the shaft to pump water to the next permanent station above the sinking operations. The pumps being used have a rated capacity of 725 gallons per minute against a 510-foot head. Several of the six pumps on hand are kept in reserve in the event of breakdown or other emergency. Two have been used simultaneously in the shaft bottom.

The Pomona (sinking) pumps are 10-stage and are driven by 3-phase, 60-cycle, 440-volt, 1,750-r.p.m., 100-h.p. vertical motors. The sinking pumps are nonoverloading, and there is little difference in their efficiency whether they are pumping against a 50-foot head or a 500-foot head, though their volume decreases as the head increases. Abrasion is kept to a minimum, as the pumps are relatively low-speed and the interstage pressure is low.

The permanent cables that have been installed are 3/0, 3-conductor, 3,000-volt, submarine-type, armored cables carrying 2,400 volts. Previous to their installation, 1/0 rubber-covered cable is used as a temporary line. The 2,400 volts are stepped down to 440 volts by underground transformer for use on the sinking pumps. The transformers are 150-kv.-a. capacity.

The permanent 3/0 cable is hung against the north end in the manway compartment. It is self-supporting and is lowered through a slot in the steel sets. The cable is anchored through a series of three plates at its top point in the shaft.

Electronic Pump Controls

Both the sinker pumps and station pumps are electronically controlled.

Station Pumps

"Probes" or vertical wires that make contact through the water are placed in the sumps to actuate the pumps in the manner and sequence desired. A short probe controls the upper water level, whereas a large one controls the lower water level.

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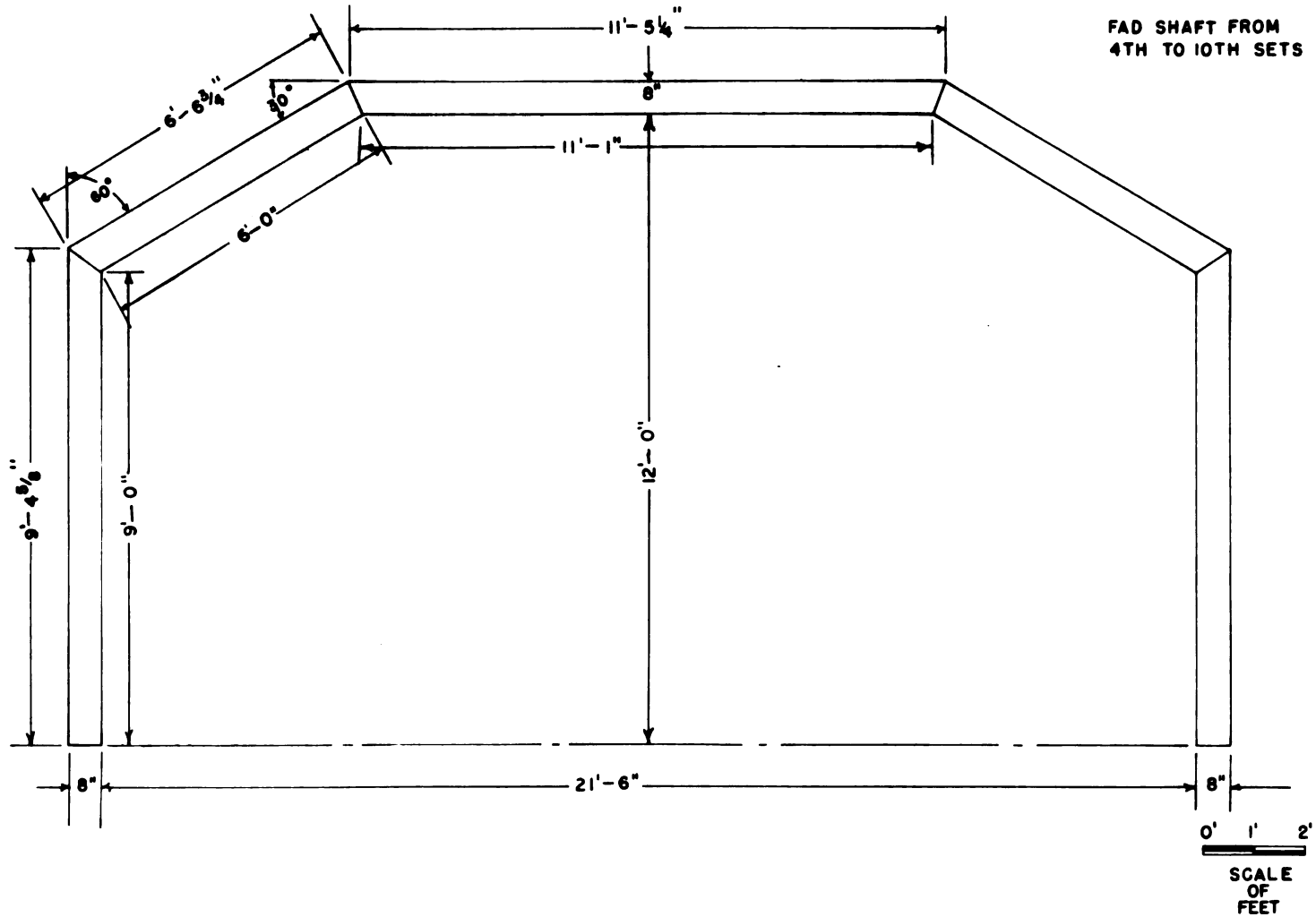

Figure 14. - Station set, 1,684' level, Fad shaft, Eureka Corp., Ltd., Eureka, Nev.

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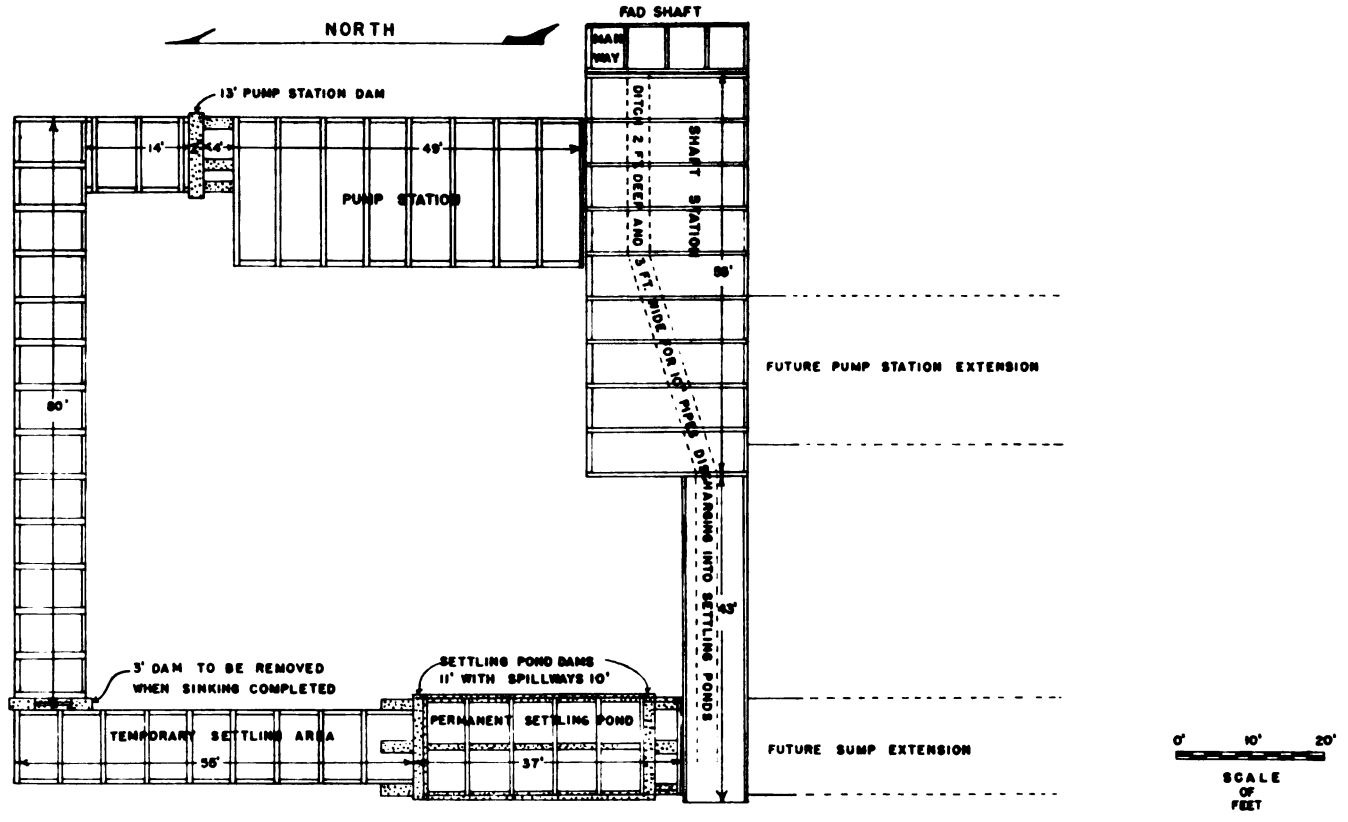

Figure 15. - 1,684 level pump station and storage dams, Eureka Corp., Ltd., Eureka, Nev.

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Rising water in the sump makes contact on the short or starting probe to start the pump that has been selected for the No. 1 position. The impulse is transmitted to the electronic control on No. 1 pump, and the pump starts. Should the pressure on No. 1 pump discharge line not come up to regular working pressure for any reason, a pressure governor shuts off the pump and sounds an alarm in the power house. All pumps are protected by a pressure governor.

If the water in the sump continues to rise, it makes contact with the short probe on the pump in No. 2 position and starts the second pump. In the same manner, No. 3 pump will cut in if required.

As the water is lowered, the pumps cut out in the same sequence as they cut in when the contact on the long or shut-off probe is broken as the water recedes below it.

Sinker Pumps

The electronic control described above is utilized for starting and stopping the sinker pumps on the shaft bottom. Instead of having "probes," as described under Station Pumps, the two probe leads on the electronic control are carried down the shaft from the control station above the bottom, at which point the sinker pump compensator is located. If the ends of the two leads are connected by twisting them together, the sinker pump starts. The pump is stopped by untwisting the ends of the two leads. The voltage in the two leads is so low that no shock is ever felt by the shaftman who starts and stops the pump. Thus, the danger of electrocution, always present with the switches formerly in use, has been eliminated.

SCALE OF WAGES

The scale of wages paid is as follows:

	Dollars per day
Hoistmen	12.44, plus bonus, depending on footage
Deckmen	10.09, plus bonus, depending on footage
Blacksmith	10.84
Surface laborers	8.25 to 9.68
Shaftmen	12.44, plus bonus
Electricians.....	10.84
Mechanics	10.84
Carpenters	10.84

Shaftmen's bonuses are approximately 5¢ per foot per man per day. 100 feet in a month equals $5 per man per day. Time and a half is paid on both wage and bonus for over 40 hours per week; double time on 7th day worked.

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